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MAINTENANCE OF RESPONDING BY SQUIRREL MONKEYS UNDER A CONCURRENT SHOCK-POSTPONEMENT, FIXED-INTERVAL SHOCK-PRESENTATION SCHEDULE

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A chain-pulling response was initially developed under a shock-postponement (avoidance) schedule with two squirrel monkeys. Few responses occurred on a lever where responding initially had no scheduled consequence or, subsequently, when a 3-minute fixed-interval shock-presentation schedule was concurrently arranged for lever responses. Appropriate rates and patterns of lever responding developed and were later maintained under the fixed-interval 3-minute shock-presentation schedule alone when the chain and shock-postponement schedule were removed. When both the shock-postponement and shock-presentation schedules were again simultaneously in effect, steady rates of chain pulling were maintained by the shock-postponement schedule and positively accelerated rates and patterns were maintained on the lever by the shock-presentation schedule. Response rates under both schedules were directly related to shock intensity. A history of exposure to a shock-postponement schedule, even though with a topographically different response and manipulandum, was sufficient for the development and eventual maintenance of responding by the presentation of shock. Further, differential performances can be maintained simultaneously by the presentation and postponement of electric shock.

Key words: response-produced shock, shock postponement, avoidance, shock-maintained responding, positive reinforcement, negative reinforcement, concurrent schedules, fixed-interval schedules, electric shock, squirrel monkeys

The presentation of a noxious stimulus such as electric shock can have a variety of behavioral effects. Under certain conditions, for example, shock presentation can suppress ongoing behavior, a process referred to as punishment (Azrin & Holz, 1966; Morse & Kelleher, 1977). Under other conditions the presentation of an electric shock can directly elicit certain responses (e.g., Hutchinson, 1977; Hutchinson, Renfrew, & Young, 1971) which can in turn be modified by their consequences (Morse, Mead, & Kelleher, 1967). Several studies have also demonstrated that response-produced shock presentation can generate and maintain appropriate schedule-controlled performances that are comparable in rate and patterning to those maintained by other events (Byrd, 1969; Kelleher & Morse, 1968; McKearney, 1968; see reviews by McKearney & Barrett, 1978; Morse & Kelleher, 1970, 1977). Significantly, electric shock can serve many of these different effects at the same time and with a single organism. For example, a number of studies have now shown that the response-produced presentation of an identical electric shock can both maintain and suppress responding in the same subject (Barrett, 1977; Barrett & Glowa, 1977; Kelleher & Morse, 1968; McKearney, 1972). Further, responding on two levers has also been maintained simultaneously by a concurrent schedule of shock presentation and by termination of the shock schedule and associated stimuli (Barrett & Spealman, 1978). These studies showing the dual behavioral effects of electric shock provide compelling evidence that the effects of environmental stimuli on behavior can depend on factors other than the stimulus itself (Morse & Kelleher, 1970, 1977).

Previous analyses of the determinants of the effects of shock presentation have emphasized primarily the importance of the organism's history and the current schedule conditions controlling responding (Morse & Kelleher, 1970, 1977). The present study focused initially on the role of prior experience in the

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development of responding maintained by response-produced shock. Squirrel monkeys were first trained under a shock-postponement or avoidance schedule using a chain-pulling response. A lever was also present during the initial phases, but few responses occurred on this manipulandum both when lever responding had no consequence and, later, when the first lever response after each 3-min period produced shock (3-min fixed-interval or FI schedule). When the chain and accompanying avoidance schedule were removed, however, responding developed on the lever and was subsequently maintained under the FI schedule of response-produced shock. Finally, both the chain-pulling and lever-pressing responses were maintained simultaneously under the shock-postponement and shock-presentation schedules respectively. These distinctive performances were characteristic of behavior maintained separately under comparable schedules and show that responding can be maintained simultaneously both by the presentation and postponement of the same electric shock.

METHOD

Subjects

Two experimentally naive mature male squirrel monkeys (*Saimiri sciureus*) were used. Each monkey weighed approximately one kg. They were housed individually and, except during experimental sessions, were provided with unrestricted access to food and water.

Apparatus

During experimental sessions each monkey was restrained at the waist in a seated position in a Plexiglas chair (modified from that described by Hake & Azrin, 1963). A BRS/LVE #121-05 response lever was mounted on the right side of the transparent wall facing the monkey. The lever was 8 cm above the waist plate and 6 cm from the center of the front wall. A minimal downward force of .20 N on the lever activated a relay mounted behind the front wall and was recorded as a response. A second lever (Gerbrands #G 6312) was positioned on the top left of the front panel, beyond the monkey's reach. A 16-cm length of chain was suspended from the lever and hung 5 cm from the center of the front panel. The bottom of the chain was approximately 10 cm higher than the other lever. A minimal downward force of .85 N on the chain also activated a feedback relay and counted as a response. Three pairs of lamps were mounted at approximately eye level behind the transparent front wall. During the experimental session the chamber was illuminated by a pair of white lights. A Plexiglas stock held the shaved end of the monkey's tail motionless. During experimental sessions the tail was coated with EKG electrode paste that ensured low-resistance contact with two brass electrodes that rested on the tail. Electric shock consisted of a 200-msec pulse from a 650-V ac 60-Hz transformer delivered through a variable resistor in series with the tail. Shock intensity was monitored by a Simpson #1257 alternating current meter. The chair was placed inside a sound-attenuating enclosure that was supplied with white noise and was equipped with a ventilating fan.

Procedure

Both monkeys were initially trained under a shock-postponement schedule that delivered shock (5 mA) every 5 sec in the absence of a response. A response on the chain postponed shock for 25 sec (Sidman, 1953). During the first five sessions the lever was present but responses on it had no scheduled consequence. At the beginning of Session 6 a 3-min FI shock-presentation schedule was placed in effect for lever responding. Under this condition the first response on the lever after 3 min produced a 5-mA shock; the shock-postponement schedule remained operative for chain pulling and was independent of the shock-presentation schedule (concurrent shock-postponement, shock-presentation schedule). After 12 sessions under the concurrent schedule, the chain and the shock-postponement schedule were removed, leaving only the lever and the FI 3-min shock-presentation schedule in effect for the next 43 sessions.

Subsequently, with monkey MS-46, the shock-postponement schedule was reinstated and responding on the lever was placed under extinction. With MS-47 the chain was reintroduced but the shock-postponement schedule was not placed in effect until seven sessions later. Responding of both monkeys was then maintained under the concurrent shock-presentation and shock-postponement schedule and several manipulations were conducted over the next approximately 200 sessions. In addition to

studying the effects of separately deleting each schedule (extinction), shock intensity was also varied from 1 to 10 mA. These changes are summarized in Table 1 which gives the sequence of experimental conditions, number of sessions, and shock intensity at each condition. Each session typically lasted 1 hr when only the shock-postponement schedule was in effect; when the FI schedule was in effect, sessions terminated after 20 FI cycles.

RESULTS

Development of Responding Maintained by Response-Produced Shock

Steady rates of chain pulling developed rapidly under the shock-postponement schedule. Responding on the lever was, at first, very infrequent and did not occur at all in the later phase of the first condition (Sessions 4 and 5). Introduction of the FI 3-min shock-presentation schedule had no effect on the chain-pulling avoidance response. The top panel of Figure 1 shows stable performance of MS-46 under the concurrent shock-postponement, FI 3-min shock-presentation schedule before both the chain and shock-postponement schedule were removed (Session 12). Moderate and steady rates of responding were maintained on the chain but no responding occurred on the lever. In the next session (second panel) the chain and shock-postponement schedule were removed and only the FI 3-min shock-presentation schedule was in effect. Steady rates of lever pressing developed within the first session and response rates increased over the next few sessions (third panel). Pronounced curvature resembling that typically seen under FI schedules (Ferster & Skinner, 1957) was apparent upon completion of this phase of the experiment (bottom panel, Session 43). Immediately after shock delivery there was a pause in responding, followed by a gradually increasing rate that continued until the next response-produced shock.

Table 1
Sequence of Experimental Conditions

Schedule		*Sessions*		*Shock intensity (mA)*	
Lever	*Chain*	*MS-46*	*MS-47*	*MS-46*	*MS-47*
Extinction	Shock postponement	1-5	1-5	5	5
FI 3-min	Shock postponement	6-12	6-12	5	5
FI 3-min	–	13-43	13-43[b]	5	5
Extinction	Shock postponement	44-46	–	5	–
Extinction	Shock postponement	47-60	–	8	–
FI 3-min	–	61-75	–	8	–
FI 3-min	Extinction	76-81	44-50	8	5
FI 3-min	Shock postponement	–	51-53	–	8
FI 3-min	Shock postponement	82-84	54-74	8	8
FI 3-min	–	85-104	75-80	8	8
FI 3-min	Shock postponement	105-145[a]	–	8	–
FI 3-min	Shock postponement	146-148	81-146[c]	10	8
FI 3-min	Shock postponement	–	147-160	–	10
Extinction	Shock postponement	149-152	161-169	10	10
FI 3-min	Shock postponement	153-155	170-182	10	10
FI 3-min	Shock postponement	–	183-191	–	5
FI 3-min	Shock postponement	–	192-206	–	1
FI 3-min	Shock postponement	–	207-216	–	5
FI 3-min	Shock postponement	–	217-226	–	10
FI 3-min	Extinction	156-168	227-240	10	10
FI 3-min	Shock postponement	169-171	241-250	10	10
Extinction	Shock postponement	172-179	251-263	10	10
FI 3-min	Shock postponement	180-187	264-270	10	10
FI 3-min	Shock postponement	188-197	–	5	–
FI 3-min	Shock postponement	198-211	–	1	–
FI 3-min	Shock postponement	212-221	–	5	–
FI 3-min	Shock postponement	222-231	–	10	–

[a]Session 109: Shock-postponement schedule changed so that each response postponed shock for 45 sec.
[b]Session 13: FI value decreased to 1 min for a portion of the session and then increased to FI 3-min.
[c]Session 134: Shock-postponement schedule changed so that each response postponed shock for 45 sec.

The development and maintenance of responding by response-produced shock with MS-47 was similar to that with MS-46 (Figure 2). Under the final concurrent shock-postponement, FI 3-min shock-presentation schedule, steady rates of chain pulling occurred that postponed shock but, as with MS-46, lever pressing did not occur (top panel). Responding did not develop rapidly during the first session with the chain and shock-postponement schedule removed (Session 13) and both the restraint chair and schedule were temporarily modified to increase the probability of responding. An artificial wall, inserted into the chair, restricted the monkey's movements to an area directly in front of the lever. The FI schedule was varied during the latter part of the session and was then changed back to the 3-min value (second panel). The artificial wall was removed before Session 14 and the FI schedule was kept at 3 min. Reasonably steady response rates developed during that session under the FI 3-min shock-presentation schedule (third panel); these rates increased over the next six sessions to a high steady rate (fourth panel). As with MS-46, positively-accelerated rates and patterns of responding by MS-47 developed over the next few sessions and, by the end of this experimental condition, responding maintained by the FI schedule of response-produced shock showed pronounced curvature (fifth panel, Session 42).

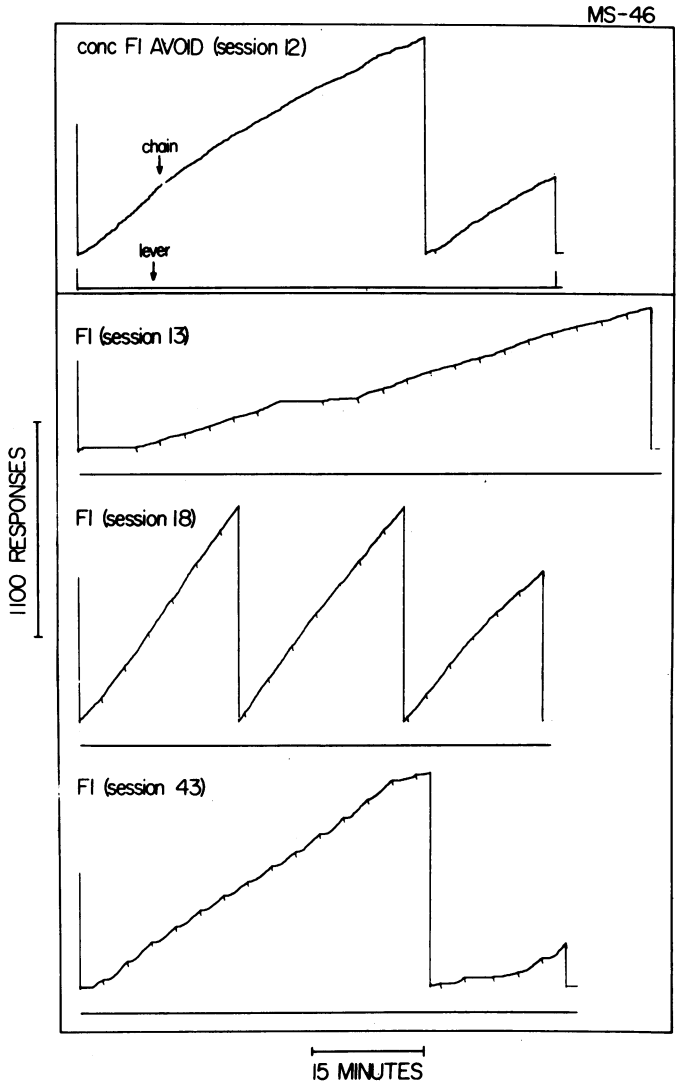

Fig. 1. Cumulative response records showing the development and maintenance of lever responding under a 3-min FI schedule of response-produced electric shock after a history of chain-pull responding under a shock-postponement schedule (MS-46). Diagonal marks on the record indicate shock delivery; the pen reset after approximately 1,100 responses. In the top panel (Session 12) both the FI 3-min shock-presentation (lever) and shock-postponement (chain) schedules were simultaneously in effect. Note that steady response rates were maintained under the shock-postponement schedules but that no responding occurred on the lever. The second panel (Session 13) shows performance during the first session under the FI 3-min shock-presentation schedule alone. Steady rates of lever pressing developed rapidly and increased over the course of the next five sessions (third panel, Session 18). The bottom panel shows the final performance under the FI 3-min schedule of response-produced shock (Session 43). Note that rates within the 3-min interval were positively accelerated.

Concurrent Performances Maintained by Shock Presentation and Shock Postponement

After responding was maintained under the FI 3-min schedule, the next phase of the study focused on the development of performances maintained simultaneously by shock presentation and shock postponement. MS-46 was returned to the original condition where responses on the lever had no consequence and chain pulling postponed shock (concurrent extinction, shock-postponement, Table 1, Session 44). Responding under the shock-postponement schedule was slightly disrupted for one session and several shocks occurred; shock intensity was increased to 8 mA on Session 47. Over the next three sessions, chain-pull responding developed to a moderate steady rate and lever pressing fell to zero where it remained for the next 13 sessions. This monkey was then returned to the FI 3-min shock-presentation schedule alone (Session 61) where performance rapidly stabilized and was similar to that shown in the bottom panel of Figure 1.

On Session 76 the chain was replaced for MS-46 but the shock-postponement schedule was not in effect (concurrent FI 3-min shock-

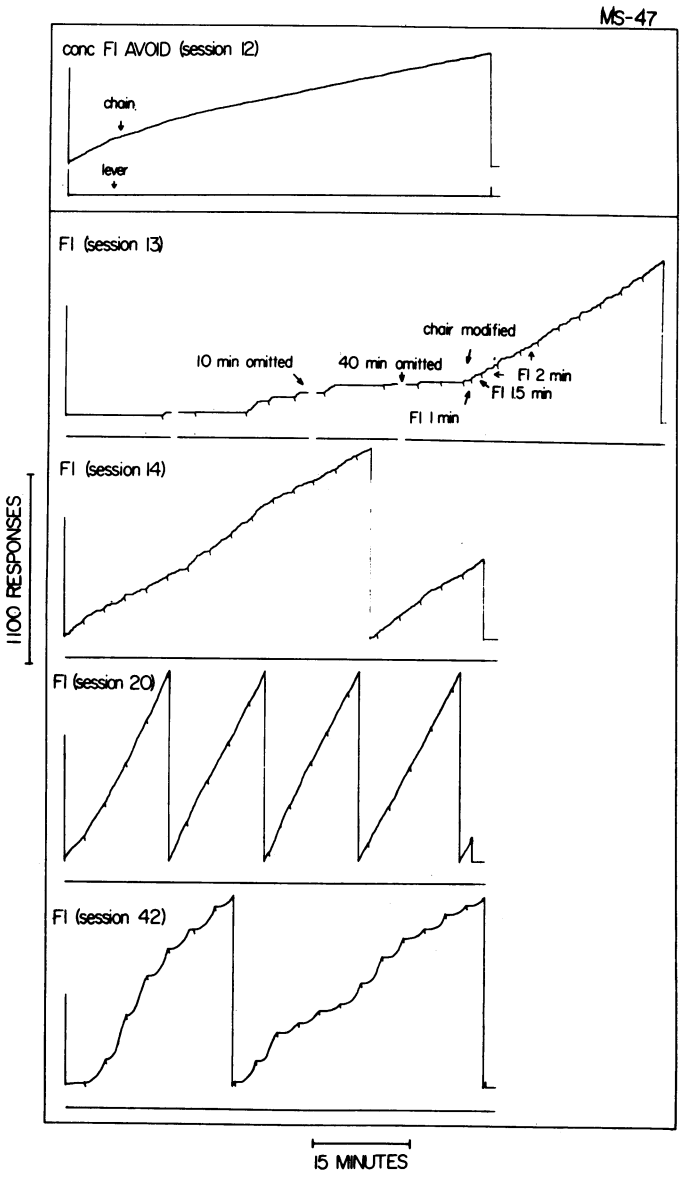

Fig. 2. Cumulative response records showing development and maintenance of lever-pressing performance by a 3-min FI shock-presentation schedule after training under a schedule where a chain-pulling response postponed shock delivery (MS-47). Diagonal marks on the record indicate shock presentation; the pen reset after approximately 1,100 responses had cumulated. Top panel (Session 12): responding under the concurrent shock-postponement (chain response) FI 3-min shock-presentation (lever response) schedule. Note that steady response rates were maintained by the postponement of shock but that lever pressing and, therefore, response-produced shocks did not occur. Second panel (Session 13): first session of exposure to the FI 3-min shock-presentation schedule with the chain and postponement schedule removed. Several minutes are omitted from the record and the schedule and chain were temporarily modified (see text). Third panel (Session 14): second session under the FI 3-min shock-presentation schedule alone. Steady rates developed rapidly and increased substantially over the next few sessions (fourth panel). Fifth panel (Session 42): next-to-last session under the 3-min FI schedule before the chain was reintroduced. Note the pronounced curvature within each FI.

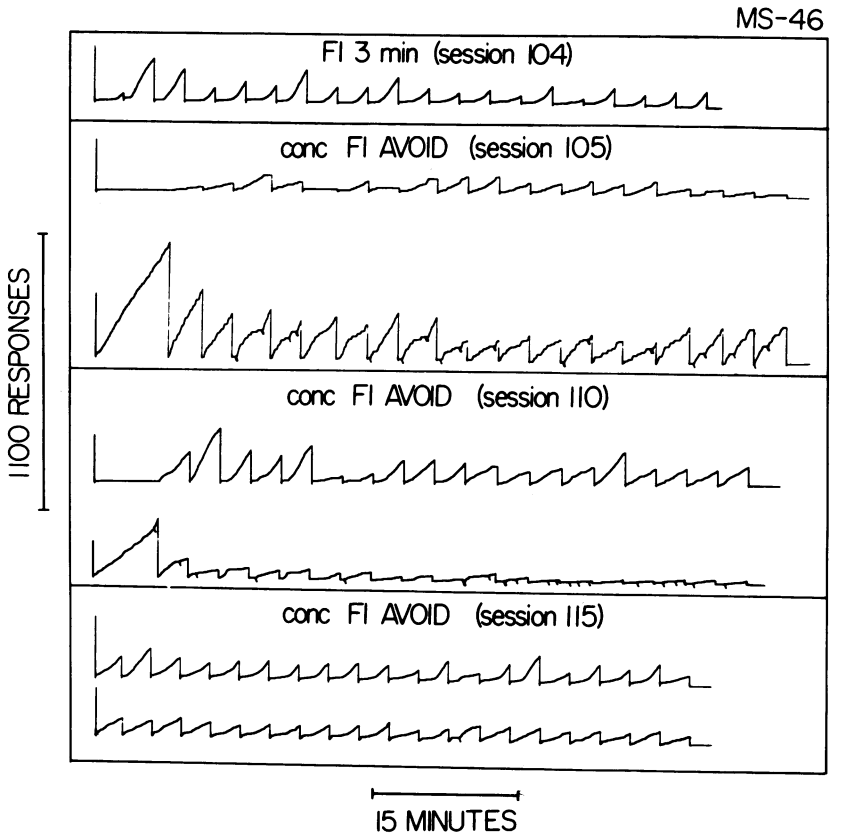

Fig. 3. Cumulative response records depicting the development and maintenance of responding under the concurrent FI 3-min shock-presentation, shock-postponement schedule (MS-46). The top panel shows lever-pressing performance under the 3-min FI alone (Session 104). The second panel was taken from the next session when the chain was replaced and shock-postponement schedule was again in effect (Session 105). Lever pressing under the FI 3-min schedule is shown in the top record of each pair. Note that although responding was initially disrupted on both manipulanda, by Session 110 (third panel) lever pressing increased and began to show positive acceleration, while chain pulling had declined and was occurring at more constant rates throughout each FI cycle. The bottom panel shows stable rates and patterns under the concurrent schedule. Steady rates of chain pulling occurred throughout the session and few shocks occurred, whereas lever responding was positively accelerated under the FI schedule. Shocks are indicated by diagonal marks on the record. Both pens reset at the end of each FI.

presentation, extinction). Over the next six sessions chain pulling fell to only 1 to 3 responses per session. Reinstatement of the shock-postponement schedule markedly disrupted responding on both manipulanda (Sessions 82-84) and the chain and avoidance schedule were again removed. Between Sessions 85 and 104 responding was maintained on the lever under the FI 3-min schedule of response-produced shock (see Table 1).

Figure 3 shows the final performance of MS-46 under the FI 3-min schedule before the chain and shock-postponement schedule were reintroduced after these several manipulations (top panel, Session 104). Once again, lever pressing under the FI schedule alone was positively accelerated and stable across sessions. The second panel of Figure 3 (Session 105) depicts the initial disruption in FI performance that occurred when the chain and shock-postponement schedule were reinstated after the intervening manipulations. In contrast to the previous sessions in which these same schedules were simultaneously in effect (Sessions 82 through 84), responding was now maintained throughout this and subsequent sessions. During Session 105 responding under the FI schedule declined to a low steady rate and responding under the postponement schedule was somewhat erratic and was characterized by bursts of responding following shock.

Five sessions later (third panel, Session 110),

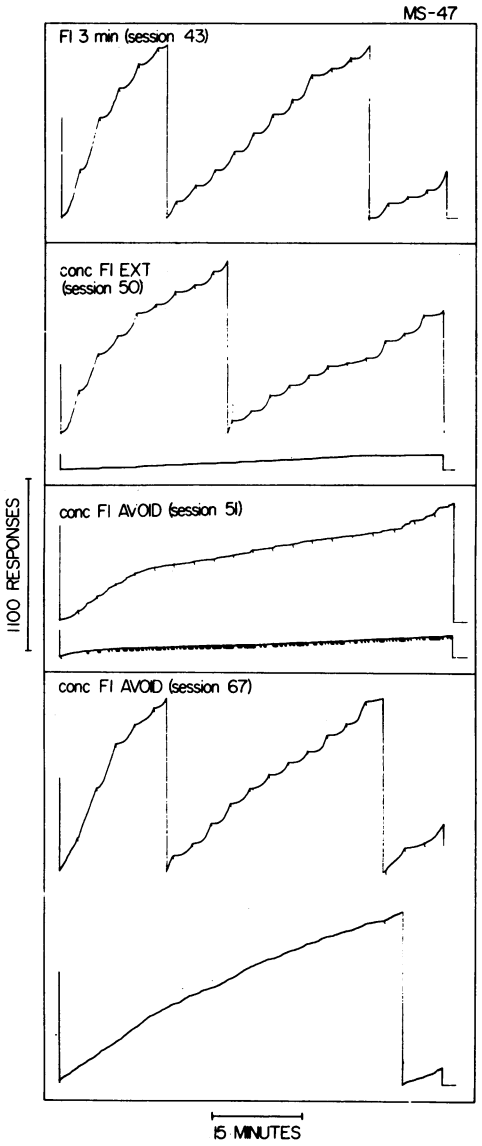

Fig. 4. Development of concurrent performances under the FI 3-min shock-presentation, shock-postponement schedule for MS-47. The top record shows responding on the lever maintained under the 3-min FI schedule (Session 43). In the second panel the chain was reintroduced but the shock-postponement schedule was not in effect (Session 50). In each panel where there are two records, the upper record represents lever pressing under the FI schedule. Panel 3 shows the first session when the shock-postponement schedule was reinstated (Session 51). Several shocks were delivered when chain pulling did not occur which disrupted lever pressing as well. The bottom panel shows performance after 16 sessions under the concurrent schedule. Steady rates of chain pulling were maintained under the avoidance schedule, whereas, simultaneously, pronounced positively accelerated rates of lever pressing were maintained by the 3-min FI shock-presentation schedule. Shock delivery is indicated by a diagonal mark on each record. Each pen reset after approximately 1,100 responses.

low but reasonably steady rates of responding were maintained under the shock-postponement schedule and there was some evidence of a return in patterning with lever pressing under the FI 3-min shock-presentation schedule. Only a few shocks were delivered when chain pulling fell to a low rate. The last panel shows that over the next five sessions steady rates of chain pulling developed under the shock-postponement schedule while, simultaneously, positively-accelerated patterns of lever pressing were maintained under the FI 3-min shock-presentation schedule.

Figure 4 shows the development of responding maintained simultaneously by shock postponement and shock presentation with MS-47. After responding had developed and stabilized under the FI 3-min schedule alone (Figure 4, top panel), the chain (but not the shock-postponement schedule) was reintroduced (Table 1). The second panel of Figure 4 shows that very low rates of chain pulling occurred under the concurrent FI 3-min shock-presentation extinction schedule (Session 50). When the shock-postponement schedule was added, FI responding was markedly disrupted and several shocks were delivered under the avoidance schedule (third panel, Session 5). The last panel of Figure 4 shows performance of MS-47 16 sessions later when responding under the FI schedule again revealed marked curvature and when steady response rates of chain pulling were maintained under the shock-postponement schedule.

Schedule and Behavioral Interactions

During the transition from the introduction of the concurrent schedule to the eventual development of stable differentiated rates and patterns of responding, occasional shocks were delivered under the postponement schedule when chain pulling decreased to low rates or did not occur. Figure 5 shows that these avoidance shocks initiated chain pulling, but produced a pause in ongoing lever pressing. Intervals in which avoidance shocks occurred resulted in multiple scallops in lever responding. These effects indicate that although both manipulanda controlled distinctly separate rates and patterns, a shock delivered under the postponement schedule had effects on re-

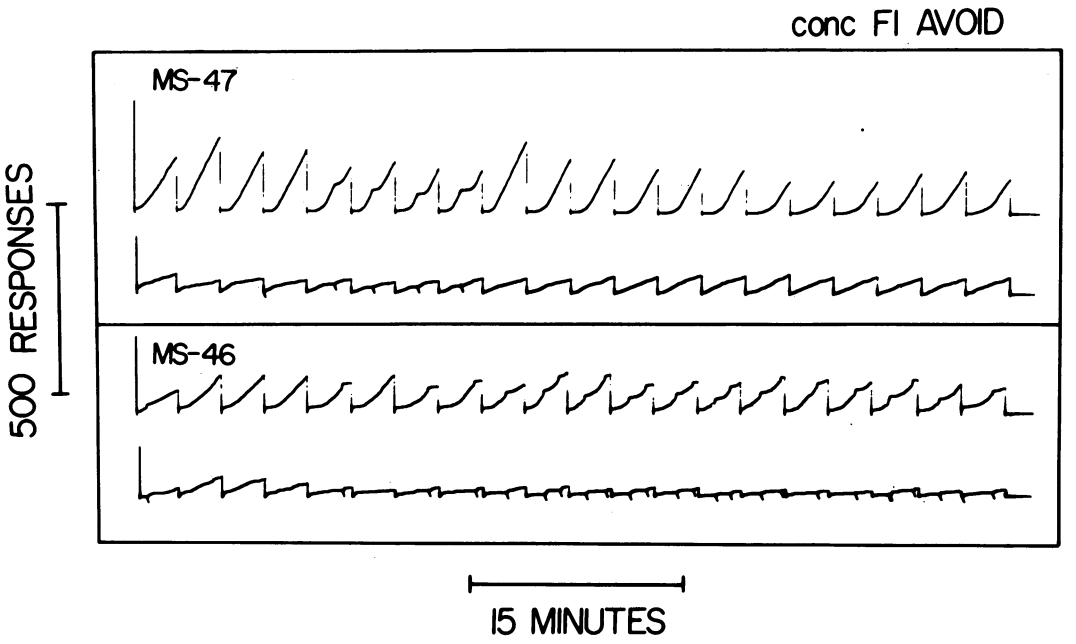

Fig. 5. Cumulative records showing interactions between performances maintained under the concurrent 3-min FI shock-presentation and shock-postponement schedule. The upper record in each pair represents lever pressing under the FI schedule; the lower record represents chain pulling under the avoidance schedule. Avoidance shocks are indicated by the diagonal slashes on the lower record in each pair. The pens reset after shock delivered under the FI schedule. Note that avoidance shocks both initiated chain pulling and terminated lever pressing. The record for MS-46 was taken from Session 128, that for MS-47 from Session 127.

sponding maintained by both schedules. There was little evidence that a response-produced shock delivered under the FI schedule initiated chain pulling with either monkey, although for MS-46 a burst of lever responding did occur following delivery of the FI shock. In the later phases of the study, avoidance shocks occurred infrequently; however, when they did, patterns comparable to those shown in Figure 5 were typically observed.

The next phases of the study (Sessions 149 through 179 for MS-46 and Sessions 161 through 263 for MS-47) examined the effects of separately removing the shock-presentation or shock-postponement schedules but not the respective manipulanda associated with these schedules (extinction). With both monkeys the FI 3-min shock-presentation schedule was removed at least twice and extinction of responding under the shock-postponement schedule was studied extensively once (Table 1). Figure 6 summarizes the effects of separately extinguishing one concurrent performance. With both monkeys response rates were higher under the FI 3-min shock-presentation schedule than under the shock-postponement or avoidance schedule (Panels A). When the avoidance schedule was removed, rates of chain pulling declined, although low levels continued to occur (Panels B). With MS-46 lever pressing that produced shock was increased slightly when the chain-pulling response decreased, but this did not occur with MS-47. Chain pulling increased when the shock-postponement schedule was reinstated (Panels C) and was unaffected subsequently when the shock-presentation schedule was removed (Panels D). Lever pressing, however, did decline substantially when this response no longer produced shock. In contrast to earlier phases the successive deletion and reinstatement of the schedule throughout this phase of the study produced minimal disruption of responding.

Shock Intensity

The effects of changing shock intensity on performances under the concurrent FI 3-min shock-presentation shock-postponement schedule are shown in Figure 7. These results are in agreement with the effects shown in Figure 6 where removal of each schedule (0 mA) re-

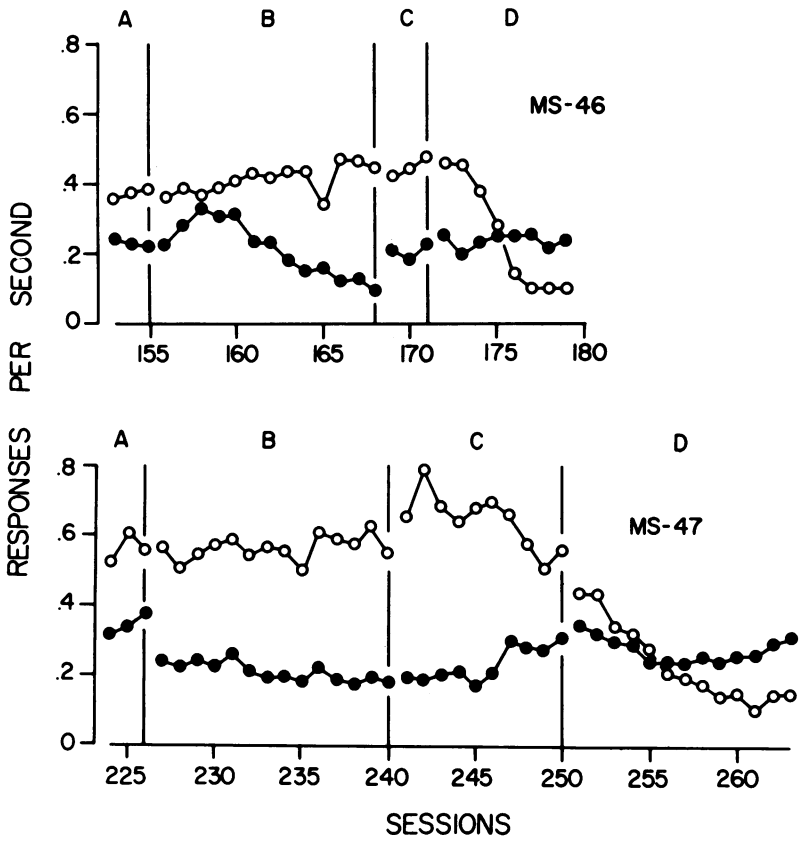

Fig. 6. Effects of extinction under the concurrent FI 3-min shock-presentation, shock-postponement (avoidance) schedule. Unfilled circles denote lever pressing maintained by the FI 3-min schedule of response-produced shock; filled circles refer to chain pulling maintained by the shock-avoidance schedule. *Panel A:* last three sessions under the concurrent FI 3-min; avoidance schedule before the avoidance shocks were removed (*Panel B*); *Panel C:* concurrent FI 3-min, shock avoidance; *Panel D:* removal of the FI 3-min shock-presentation schedule.

sulted in a decrease in responding. As shock intensity was increased from 1 to 10 mA response rates on the lever and chain also increased. With MS-47 response rates changed little beyond 5 mA. Generally, rates of lever pressing changed more than rates of chain pulling, which probably reflects the fact that more response-produced shocks occurred than did avoidance shocks; very few shocks occurred under the avoidance schedule at any intensity.

DISCUSSION

In the present study a new and topographically different response was developed and maintained under a schedule of response-produced shock after prior training of a different response under a shock-postponement schedule. Significantly, lever pressing maintained by shock presentation emerged when the ongoing rate of responding on the lever had been extremely low, but was made more probable when chain pulling, controlled by the shock-postponement schedule, was precluded by removal of both the chain and accompanying schedule. It would appear that a history of responding maintained by shock postponement, even though such experience occurs with a different response, is sufficient for the development and eventual maintenance of responding by shock presentation. It has already been shown that a history of responding under a shock-postponement schedule is not necessary for the maintenance of responding by response-produced shock presentation (Kelleher & Morse, 1968).

After separate training under the shock-postponement schedule and the FI schedule of response-produced shock, responding of monkeys in the present study was maintained

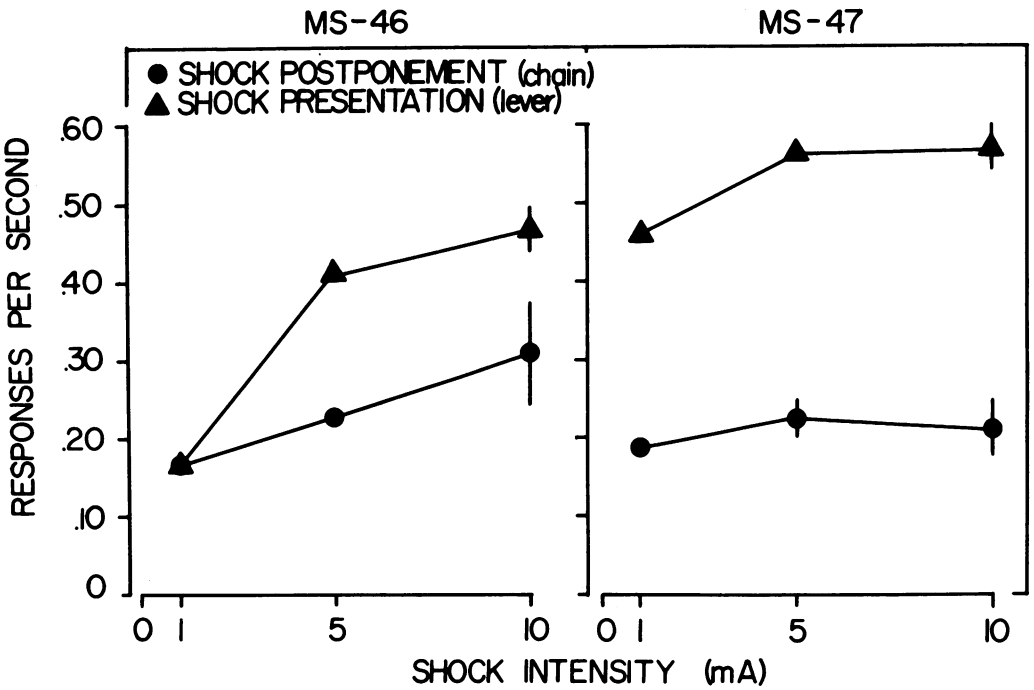

Fig. 7. Effects of changes in shock intensity on performance under the concurrent shock-postponement FI 3-min shock-presentation schedule. Data represent the mean response rate for the last three sessions at each value. Vertical bars denote the range; where there are no vertical lines, all measures were encompassed by the point.

when both schedules were simultaneously in effect. Performances maintained under the FI schedule were positively accelerated within the FI while, at the same time, the shock-postponement schedule controlled steady rates of responding. The same physical stimulus, electric shock, controlled behavior simultaneously both by its presentation and postponement. According to traditional concepts of positive and negative reinforcement (Skinner, 1953), in the present study shock was *both* a positive and negative reinforcer, maintaining responding, respectively, by its presentation and postponement. Similar dual functions of shock have been reported previously under situations where responding was simultaneously maintained by shock presentation and by the termination of a shock-presentation schedule and associated stimuli (Barrett & Spealman, 1978).

Other experiments have shown that shock presentation can also both maintain and suppress behavior (Barrett, 1977; Barrett & Glowa, 1977; Kelleher & Morse, 1968; McKearney, 1972). The many different effects of electric shock on behavior depend predominantly on the organism's behavioral history and the current schedule and environmental conditions (Morse & Kelleher, 1970, 1977).

Multiple behavioral effects produced by the same physical stimulus are not confined to shock. It has been known for some time that responding can be maintained simultaneously by food presentation and by the termination of visual stimuli associated with the food-presentation schedule (Azrin, 1961; Brown & Flory, 1972; Thompson, 1964). Further, when responding was maintained under a variable-interval schedule of shock (Barrett, 1975) or food presentation (Azrin & Hake, 1969), presentations of a visual stimulus associated with response-independent food delivery suppressed responding. Clark and Smith (1977) and Smith and Clark (1972) have reported experiments in which substantial rates of responding can be maintained by the postponement of food in food-deprived organisms. Recently, Spealman (1979) has shown that responding can be maintained simultaneously by intravenous cocaine administration and by the termination of visual stimuli correlated with the schedule of cocaine injections. Still other studies have

shown that the same drug that functions as a *maintaining* event under one condition will *suppress* behavior under a different condition (Wise, Yokel, & Dewit, 1976). Together, these many findings encompassing a range of stimuli other than electric shock show quite clearly that the effects of shock on behavior are not unique, nor do they reflect isolated, atypical outcomes. These results do suggest, however, the more general conclusion that the principles of reinforcement and punishment are not dependent on intrinsic properties of the event.

Some of the different effects of electric shock on behavior were evident in the present experiment when avoidance responding fell to a low level and shock was delivered. If FI lever responding was occurring the delivery of an avoidance shock produced a pause in lever pressing, followed by the development of a second positively-accelerated pattern (Figure 5). This finding indicates that even though the two shock schedules maintained two distinct patterns of responding, a degree of interaction still existed suggesting that shock was serving both a discriminative and reinforcing function. Further, the interruption of lever responding by the avoidance shock, followed by another pattern of positive acceleration would also seem to suggest that temporal factors, per se, were not solely responsible for the maintenance of the positively-accelerated performances under the FI schedule.

The development of concurrent performances maintained both by shock presentation and shock postponement was slightly different for the two monkeys in this study. For MS-47 lever responding under the FI schedule initially required a slight temporary modification of the restraint chair and schedule to increase the likelihood of lever pressing and contact with response-produced shock. Few shocks were necessary, however, for the initiation of responding which was then sustained over the course of the entire experiment. Responding was only slightly disrupted with MS-47 when the chain and, later, the avoidance schedule were reintroduced. With MS-46 lever pressing maintained by response-produced shock developed rapidly. Stable concurrent performances developed only after the shock-postponement schedule and chain were deleted and reinstated a number of times (Table 1). The difference in the development of concurrent performances with the two monkeys may have been due to the different procedures followed; i.e., with MS-47 the initial reintroduction of the chain was made without the avoidance schedule and minimal disruption of lever pressing occurred with this procedure. It was only after extensive training under the FI 3-min schedule with the lever-pressing response that introduction of the shock-postponement schedule and chain had a minimally disruptive effect for MS-46.

It would appear that responding maintained by response-produced shock may be initially more sensitive to disruption by concurrently scheduled events and that procedures which minimize the disruption of this performance will more likely result in the eventual establishment of responding by both schedules. Once responding has been well maintained, however, subsequent manipulations appear to have different effects and do not result in a loss of schedule control. In the present study responding maintained by both shock presentation and shock postponement was ultimately durable and well maintained, yet still remarkably sensitive to modification of the parameters of shock intensity and schedules. These results are similar to those described by Morse and Kelleher (1966) as metastable where two different patterns of responding are maintained under the same schedule conditions after an interpolated condition. Metastable performances, although not limited to schedules of response-produced shock (e.g., see Staddon, 1965), do characterize the findings reported here in that they emphasize that emergent behavior depends upon both antecedent behavioral experience and current environmental conditions.

Research in which responding has been maintained by response-produced shock has been important in several respects. First, it has forced attention away from restrictive conceptualizations of events based on inherent characteristics. A more general account of the determinants of reinforcement and punishment exists that is based instead on the behavioral effects of those events (Morse & Kelleher, 1977). Second, findings with the maintenance of responding by shock presentation emphasize the importance of behavioral history and current environmental factors, thereby allowing an experimental approach to entirely new

problems that have not previously captured much attention.

Finally, although many have focused on the apparently enigmatic nature of shock-maintained responding, it would seem much more useful to concentrate on the similarity of the processes by which events in general eventually differentiate and maintain behavior. With shock, as well as with food and other stimuli, some preliminary experience is often necessary for that event to function effectively as a reinforcer. With food, appropriate deprivation levels may be necessary, whereas with shock some previously established level of responding may be essential. Both preliminary conditions make the occurrence of a response, and therefore a consequent event, more probable. Behaviorally effective stimuli also appear to have strong eliciting properties. For example, events as diverse as the delivery of food (Reid, 1957), shock (Hutchinson et al., 1971; Morse et al., 1967), drugs (Downs & Woods, 1975; Goldberg, Hoffmeister, Schlichting, & Wuttke, 1971; Woods, Downs, & Carney, 1975) and an imprinting stimulus (Hoffman, Stratton, Newby, & Barrett, 1970; Stratton, 1971) can elicit responses which can subsequently undergo progressive differentiation when those same events are arranged as response consequences. Rather than being paradoxical and not fitting within a traditional theoretical framework, the maintenance of behavior by response-produced shock reaffirms and amplifies principles that are of widespread and fundamental importance in the analysis and understanding of behavior.

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